ACTION LINES OF MUNICIPALITIES TO IMPROVE THE SUSTAINABLE DEVELOPMENT OF SMALL AND MEDIUM-SIZED CITIES IN THE EU

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Abstract

More and more knowledge, economic and social resources and activities are concentrated in small and medium-sized cities as development centres; this applies in full to the EU countries. This poses huge sustainability challenges and responsibilities for cities municipalities. The UN has defined the comprehensive vision of the sustainable development (SD) in three dimensions: economic, social and environmental. The present study is devoted to the most objective mathematical identification of the priority action lines for the cities municipalities, which correspond to the functionality of the municipality and ensure optimization of the data-driven SD of the city in accordance with the globally accepted UN SD vision. To achieve the goal, the adapted data mining methods are used, which are well suited to discover and generate the knowledge about the existing regularities in data sets, similar to those describing SD. Recommendations for practical activities within the action lines are provided.

Keywords: *sustainability, agenda 2030, sustainable urban development, local governance, key performance indicators, benchmarking modelling*

1. INTRODUCTION

The concept of global development has been continuously advancing and improving with the development of the world. In the last decades of the 20th century a wide-ranging global debate among high-level experts and politicians focused on the next naturally arising issue: how to make human development process sustainable. The concept of sustainability, as the political compromise defined by experts, covers various interrelated long-term economic, social and environmental aspects (see, e.g.: Boer & Hueting 2004). Several successive political-programmatic stages resulted in the adopted by the UN General Assembly *Agenda 2030* that is a "plan of action for people, planet and prosperity" (UN 2015a). The program defined the extended sustainable development (SD) vision: a holistic vector of global progress, incorporating balanced integrated solutions to the economic, social and environmental dimensions. Seventeen sustainable development goals (SDG) were set; these are directed to the implementation of the multidimensional *Agenda 2030* vision. Many indicators have been defined for each SDG to show progress on various aspects made through the performed concerted activities (see also Eurostat 2021).

The urban dimension appears in this document (SDG11) and in UN publications (see UN 2015b) too. Looking at the global development trends, this is perfectly understandable. Urbanization is considered to be one of the trends in the 21st century that will transform the world the most. Although the pace of urbanization is slowing down, cities continue to attract the population. 74.9% of the European population resided in urban areas in 2020 (UN 2019), majority of them in small and medium-sized cities (see also Ritchie & Roser 2020).

Cities have already become the centres of development, creating the global economic growth, transferring know-how and benefits to surrounding rural areas too. At the same time, the cities are also responsible for the sustainability of development due to the resources used, increased warming and pollution, criminality, overcrowding, etc. (the COVID-19 pandemic experience makes this very clear).

Taken together, this shows that nowadays the concept of the SD, both the benefits and the problems, is actually transferred to the city level, including small and medium-sized cities.

The UN considers the improvement of human settlements management as an important aspect of SD (UN 2015b). "As the world continues to urbanize, sustainable development depends increasingly on the successful management of urban growth" (UN 2019). The impact of municipal policy and its performance is no longer limited by the city borders; they also affect the national level.

This poses serious sustainability challenges for cities' municipalities. The municipality needs to work in a huge number of complex action lines regarding healthcare, education, transport, energy, water, waste services, as well as housing, infrastructure, decent jobs, security, environment to ensure growing quality of life for population of the city and to promote it for surroundings.

The benefits of an action line performance are reflected by a relevant indicator (fig. 1). The more general the indicator, the wider performance it brings together, resulting from several action lines; the availability of much more specific data would show the result of each individual action line. The indicators are suitable for quantifying results and are therefore used more frequently.

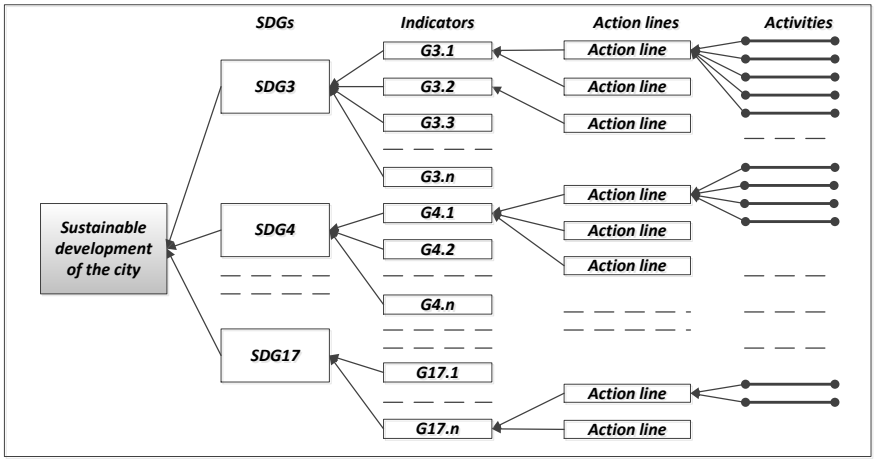


Fig. 1. Relationship of the action lines and SDGs in the sustainable development of the city

Developed by authors, partly based on UN documents.

Experts have created a number of sets of urban indicators and integrated indexes to evaluate performance of the city municipality; they cover a wide range of economic, infrastructure, environmental, health, safety, mobility, educational and cultural indicators (see, e.g., Sharifi 2020). The set goals are similar in all cases; they are aimed at sustainable growing quality of life of the city's population, although different future urban forms are highlighted (Yakoub et. al. 2019): sustainable city (Arcadis 2018), smart city (Bee smart city 2017; CITYkeys 2017; IMD 2019), liveable city (Sasanpour 2017; EIU 2019), eco-city (Bulkeley & Marvin 2014).

A slightly more detailed analysis reveals a number of shortcomings: the sets of indicators (1) are selected voluntarily, whether they are a priority is unknown; (2) include national level indicators, e.g., economic freedom, censorship and even geographical indicators, e.g., humidity and temperature, which don't relate to the functionality of municipalities; (3) include indicators specific to large cities only, e.g., data on metro, international flights, Nobel Prize winners; (4) are not consistent with the UN SD vision, which is developed by high-level experts and globally politically accepted.

In general, the indicators and the corresponding action lines selected in this way are poorly usable for the planning and implementation of data-driven SD in a particular city; they do not show the vectors for municipalities to promote and accelerate the city's SD. They are not applicable at all to small and medium-sized cities (between 5000 and 100 000, even up to 500 000 residents).

The aim of current research is development of the methodology for objective mathematical identification of the priority action lines to increase the quality of life of the population, which correspond to the functionality of the city's municipality and ensure optimization of the data-driven SD of the city in accordance with the globally accepted UN SD vision. The methodology will be applicable for SD planning in any city, including small and medium-sized ones.

2. DETERMINATION OF THE SDGS APPLICABLE TO THE CITIES

The vision of the sustainable urban development, endorsed by the UN General Assembly (UN 2017), recommends dozens of various broad action lines to municipalities to implement the SD paradigm. To achieve our aim, we will briefly explore which SDGs apply to the functionality of urban municipalities.

There is a stand-alone SDG11 in the *Agenda 2030* related to the cities and urban development. A number of targets have been declared for its implementation, several of them are more detailed in other SDGs:

- ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums (SDG6, SDG7);
- reduce the number of deaths and the number of people affected (SDG3, SDG5);
- reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management (SDG12, SDG13);
- provide universal access to safe, inclusive and accessible green and public spaces (SDG15).

There is also recognition of the cross-cutting nature of urban issues, which are interlinked "with a number of other SDGs, including SDGs 6, 7, 8, 9, 12, 15, and 17 among others" (UN 2015b). We also considered SDG4 (Quality education) and SDG16 (Peace, justice and strong institutions), related to "human resource development and capacity building", as important for the urban level.

In turn, we did not include in the study several SDGs as inconsistent with functionality of municipalities:

- SDG14 and its indicators do not correspond to the city level; even municipalities of the cities by the sea cannot really influence the progress.
- Poverty and hunger in the UN comprehension are not relevant in the EU27. The UN mentions eradication of extreme poverty, measured as people living on less than $1.25 a day, as a SDG1 key target; the Eurostat, as characteristics of the severely materially deprived people, has been included lack of resources for a car and a week holiday away from home. The reduction of prevalence of undernourishment is an UN SDG2 key target, while the Eurostat SDG2 indicators contain even the obesity rate (Eurostat 2021).
- The key target of the SDG10 is to achieve and sustain income growth of the bottom 40 percent of the population. The EU27 average value of this indicator has remained virtually unchanged since data had become available (2006). In countries changes are stochastic ones, maximum within a few percent. Reducing inequality is possible only as a result of national political settings and decisions – minimum income level, minimum wage level, distribution of benefits through the tax system, etc.; they are and can be only very marginally influenced by municipalities.

So 13 of 17 SDGs relate fully or in part to the functionality of the city council and municipality: SDG3, SDG4, SDG5, SDG6, SDG7, SDG8, SDG9, SDG11, SDG12, SDG13, SDG15, SDG16, SDG17 (see fig. 1). This means that the municipality should work simultaneously on many different action lines to achieve progress in SD. It is absolutely clear that no municipality can perform all of them, even in part, due both for the insufficient capacity to cover the whole very wide spectrum and inability to invest immediately and simultaneously in all action lines. The prioritization of the action lines is an essential, sometimes even critical factor for many municipalities.

3. THE WORKING HYPOTHESIS AND METHODOLOGY

In order to achieve the stated aim, a working hypothesis was put forward: considering that all the SDGs are focused on the SD progress, the achieved city SD level (Y) is a multi-parameter function (f) from the set (Π) of key performance indicators (KPI) (i_1, i_2….i_n) describing the progress achieved due to the performance of corresponding action lines:

$$Y = f(\Pi) = f\{i_1, i_2, \ldots, i_n\}$$

So, the identification of KPIs will also mean the identification of related action lines that are prior for the growth of urban sustainability.

Achieving the aim of the study by direct theoretical calculation of the function (f) is a practically impossible task. However, there are several multi-dimensional analytical methods that are in principle suitable for studying cause and effect relationships between input/independent variables (indicators related with the action lines (i_1, i_2, …, i_n)) and target/dependent variable ((Y), which describes sustainable urban development) without exploring the internal aspects of the process (black box principle).

This applies to the data mining technologies, including algorithms of the regression analysis and benchmarking. We used them to determine the causal relationships between the indicators of SDGs as independent variables (predictors) and some integrated SD indicator as a dependent (target) variable (Y) in order to obtain information about the most important predictors (so activity lines) of the SD process. The general algorithms were adapted for our task; the found result is mathematically calculated, which is a huge advantage over a voluntary set of the predictors.

The regression analysis algorithms can be applied using an already known data set. This factor shows the impossibility to search the mathematical expression directly at the city level due to the lack of complete data sets. To achieve the set goal, we analysed the possibility to process data of the EU27 countries because of the homogeneous environment with the EU cities. The EU27 level data sets include indicators on countries of different sizes with different populations, including relatively small countries with small populations (e.g., Luxembourg, Malta). There are indicators that are neutral in relation to the size of the area covered (e.g., percentage of the total number of population or enterprises, of area or total amount, etc.). The linking of indicators to the concrete country may be in no way defined and/or used in the development of the mathematical model. In general, this means that the mathematical expression found can also be used to estimate the SD of cities.

The relatively abundant data sets are available at EU27 country level, including not only statistical data from the Eurostat, but also data from other sources, i.e., The Organisation for Economic Cooperation and Development, The World Bank, The Council of European Municipalities and Regions, The Digital Agenda Scoreboard, The European Innovation Scoreboard. Data are processed according to unified methodologies and regularly updated. Sufficient data is available from which to select predictors for modelling. Therefore we chose the data sets on EU27 country level as input indicators for the data mining and modelling.

We performed the benchmarking modelling at the national level to determine the KPIs and to obtain the mathematical expression sought (fig.2). By extending the expression to the city level, we defined the priority action lines that fit in the municipal functionality framework. Performing activities within these action lines, the municipality can achieve the optimum improvement of the city's SD level.

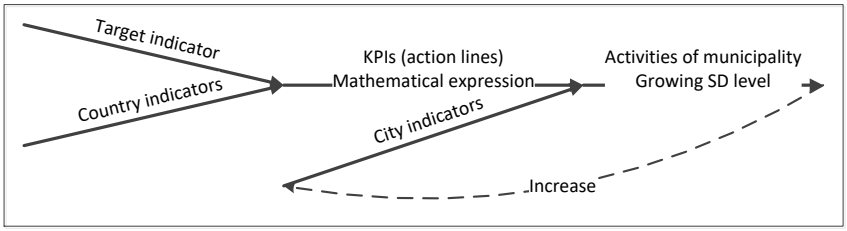


Fig. 2. The sequence for determination and usage of the priority action lines

Developed by authors.

4. DATA MINING STRATEGY AND MODELLING

A number of regression analysis methods can be used for data mining. Applying different methods, very different mathematical expressions of models are obtained, but they usually give very comparable qualitative results, as shown also by the previous experience of authors using different modelling procedures for the same task (Zuters et. al. 2016; Sarma et. al. 2019). The linear regression mathematically is the simplest method. The obtained model is a linear expression; there is a simple and clear interpretation of the model, as well as that can be easily calculated without special knowledge in mathematics and programming.

The dependent variable (Y) for the data mining should be fully consistent with the SD vision of the *Agenda 2030*: balance and integrity of economic, social and environmental dimensions. A suitable tool – the Advanced Human Development Index (AHDI) – has been created (Karnitis, Bicevskis & Karnitis 2021) by refining the popular Human Development Index HDI according the *Agenda 2030* vision. It provides unity and concordance of all included well-known and accepted comprehensive dimension indices. The multidimensional ideology of the AHDI is fully consistent with the basic principles of the SD of both large and small areas. We used the AHDI as dependent variable (Y) for modelling.

Direct transfer of global indicators (components of the AHDI) to the urban level is neither possible nor targeted, as they cover national economic, regulatory and other aspects, which are determined and widely used at a high political level. They cannot be defined at the level of an individual city (e.g., Gross National Income, Purchasing Power Standard, schooling years, etc.) as well as cannot be influenced in any way by the municipality. For the motivated development of the city, the input data set should include indicators related to the action lines that are within the competence of the municipality.

In fact, the set of the SDGs already detail the UN's understanding on the SD format, while related indicators show progress towards achievement of each SDG as the result of performed action lines. This means that the set of selected independent variables (i_1, i_2, …, i_n) should include indicators corresponding to one (or several) SDGs. To achieve the objective selection of the priority action lines (KPIs) by the modelling process, as many quantitative indicators (which relate to the municipalities) as accessible were selected and tested for each SDG (49 indicators in total, see Appendix). The achieved level of compliance of the model's target values AHDIm to the real values AHDI (mutual correlation) served as a quality criterion of the modelling procedure. The determination coefficient R^2 was used as the unit of correlation during the modelling.

According to the UN's vision of a balanced SD, all SDGs were equally represented in the search for KPIs in the modelling process; sequentially one indicator from each set of selected indicators related to 13 SDGs was used as predictor in each individual modelling procedure. There were gradually tested all possible combinations of predictors (more than 1.7 million in total) to disclose mathematical expressions (f) in which the predictors are mutually compatible, and the progress of all used predictors has a positive effect on the progress of the target variable AHDIm. 232 such *good* combinations were identified; they were analysed for determination of statistically significant indicators.

15 indicators of the 49 ones have been recognized as statistically significant using even low threshold for the evaluation of predictors' significance: the probability for a null hypothesis (p-value) is less than 0.1. These indicators were dividing into two drastically diverse groups by the intensity of their inclusions in the *good* combinations: eleven indicators were represented less than 10 times each, while six indicators more than 25 times each. Using only these six indicators (Table 1) as predictors we performed a special modelling procedure and identified the mathematical expression which reflects reality with very high accuracy (fig. 3).

```
lm(formula = AHDI ~ G3.1 + G6.2 + G7.2 + G9.2 + G12.1 +
G16.2,
    data = cdata)

Residuals:
      Min        1Q    Median        3Q       Max
-0.0258894 -0.0097836  0.0009519  0.0097435  0.0205207

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.6527891  0.0271707  24.025 3.17e-16 ***
G3.1         0.0012563  0.0003474   3.616  0.00172 **
G6.2        -0.0015960  0.0006414  -2.488  0.02177 *
G7.2        -0.0019518  0.0004514  -4.324  0.00033 ***
G9.2         0.0013329  0.0003853   3.459  0.00248 **
G12.1        0.0006729  0.0002549   2.640  0.01569 *
G16.2        0.0010646  0.0002109   5.048 6.16e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01472 on 20 degrees of freedom
Multiple R-squared:  0.9421,    Adjusted R-squared:  0.9247
F-statistic: 54.25 on 6 and 20 DF,  p-value: 2.502e-11
```

Fig. 3. Outcome of the special modelling procedure.

	Key Performance Indicators	*Long and healthy life*	*Know-ledge*	*A decent standard of living*	*Preserved environment*
G3.1	Share of people with good or very good perceived health, % of population aged 16 or over	P	s	s	
G6.2	Population not having indoor flushing toilet for the sole use, % of population	P			P
G7.2	Share of population unable to keep home adequately warm by poverty status, %	P	s	s	
G9.2	Percentage of enterprises who have ERP software package to share information between different functional areas (10+ employees)		s	P	s
G12.1	Recycling rate of municipal waste, % of generated	s		s	P
G16.2	Perceived independence of the justice system, % of population perceived as very good or fairly good	s		P	s

Table 1. Impact of the KPIs/action lines on SD dimensions; P – primary impact, s – secondary impact.

Developed by authors

5. RESULTS: APPLICATION IN CITY MUNICIPALITIES

The quality of the obtained modelling result, which is confirmed by the excellent correlation with AHDI and the statistical significance of all predictors, gives confidence that these six mathematically selected predictors can be defined as SD KPIs. When transferring the results at the city level, these KPIs show the related action lines, which are the priorities for the SD of the city. Of course, the results

obtained could be applied to the cities of the EU countries, because (1) benchmarking modelling was performed in the normatively relatively homogeneous territory of the EU27 and (2) the values of the independent and dependent variables are limited by their indicators in the EU countries.

One can see the multi-dimensionality and interconnection of the SDGs, the same relates to the calculated KPIs and the corresponding action lines: any execution affects several SD dimensions (Table 1). Thus, e.g., performed action lines to improve perception of person's health (G3.1) primarily leads to the prognosis on the better long-term health and the longevity. But it also increases his/her motivation to acquire new knowledge thus getting a better job and improving one's financial situation.

It is understandable that the municipal level is quite strongly regulated by EU and national normative acts to implement EU and national policies. Nevertheless the local governance in all EU countries is organized on the basis of the representative democracy (CoE 1985, Article 3). The city council, representing electors, should take decisions and municipality should perform activities in a way, which are understandable for, directed to and implemented in active interaction with residents, entrepreneurs, organized civil society (NGOs). That concerns not only autonomous competences, but also those delegated by state powers (CoE, Article 4.5). The discovered KPIs and related priority action lines we recommending in the table 2 (but not only) will help municipalities to find a reasonably balanced vectors in the use of its usually limited resources between regulated autonomous and delegated competences and initialized initiatives "to improve community life, maximising participation and involvement through active citizenship" (Burton & Kagan 2009).

KPI	*Action lines*	*Activities*
G3.1	Promoting a healthy lifestyle for the population	Development of sports and leisure infrastructure
		Organization of amateur sports activities and cultural events
		Facilitating healthy lifestyle in schools
		Support for entrepreneurs, promoting a healthy lifestyle for their employees
	Access to health care	Regulation of the primary and secondary health care
		Support of general practitioners and secondary ambulatory health care: premises, Internet connections, etc.
		Accessibility of public healthcare: closer and cheaper
		Ownership of outpatient departments, hospitals and nursing homes
G6.2	Organization of the water supply and sewerage services for the population	Using ownership of municipal enterprizes
		Performing public procurement
		Development of the centralized networks
		Facilitating affordability of and connections to the centralized networks
	Improvement of the technical condition of dwellings	Modernization of inside-house networks
		Co-financing development projects of inside-house networks
G7.2	Organization of the heat supply services for the population	Using ownership of municipal enterprizes
		Performing public procurement
		Development of the centralized networks
		Facilitating affordability of and connections to the centralized networks

	Improvement of the technical condition of dwellings	Modernization of inside-house networks
		Co-financing development projects of inside-house networks
		Increasing energoefficiency of buildings
	Provision of the necessary social assistance to the population	Social subsidies
		Social apartments
		Facilitating development of housing (rental market)
G9.2	Modernization of business processes in municipal capital companies	Using ownership of municipal capital companies
		Training courses for management
	Facilitation of and support for modernization of enterprises in the administrative territory	Co-operation with entrepreneurs associations
		Indirect support of the business process innovation
		Training courses for management
		Conditions for participation in municipal projects
	Requirements for investors	Requirement of the usage of the ERP independently of sector
		Targeted indirect support
G12.1	Organization of the municipal waste management and recycling	Regulation by local legislation
		Participation in working out regional plans of waste treatment
		Using ownership of waste treatment enterprizes
		Conditions for public procurement among private entrepreneurs
G16.2	Elimination of corruption and other irregularities in the city council, municipality and subordinate institutions	Performing public integrity programs
		Municipal Ethics Commissions
		Organization of the efficient Internal Audit
		Co-operation with the civil society
	Cooperation with public administration to eliminate shortcomings in public administration institutions and capital companies	Co-operation with government
		Impact on the national Parliament and government by lobbying common interests through Association of Local Governments

Table 2. Priority action lines and indicative activities

Developed by authors

At the same time level of municipal *freedom* slightly differ from country to country. In any case municipalities have responsibilities, rights and opportunities to perform own specific activities, which also naturally differ from municipality to municipality. Consequently, the activities to be taken within the action line are also specific to each city; for the implementation of the defined action line, they should be chosen by the municipality depending on the situation in the particular city. The recommended activities outlined in the Table 2 should be considered as illustrative and indicative.

6. DISCUSSION AND CONCLUSIONS

The algorithm used ensures the most possible objective selection of KPIs and related priority action lines associated with various SD aspects. Mathematical calculation is a huge advantage over a traditional voluntary preference of some indicators. A large number of currently available indicators

have been tested to select priority action lines; the developed algorithm allows testing new indicators in the future as data gathering improves.

The calculated set of priority action lines is applicable to any city, including small and medium-sized ones. They correspond to the functionality of the city council and municipality – regulation and administration in the sectors of local government autonomous functions and delegated public administration tasks, provision of services financed or co-financed by the budget and paid services, maintenance and development of public infrastructure, promotion of the civil society and business development. The selected set contains limited number of realizable action lines; it is compliant with the UN vision and the SD paradigm.

The city municipality can monitor these action lines and take them into account, making sustainable policy decisions and performing programming process of the allocation of the municipal resources. It would help also to balance cross-sectoral links, e.g., between the economy and the public health care during the post-COVID recovery. Local politicians acquire a strong basis for dialogue with the central politicians. In total, the serious improvement in the city management practice becomes possible on the way towards the data-driven SD of the city.

ACKNOWLEDGMENTS

The study has been supported by the University of Latvia project Z-LZP69-ZF-N-231 (Latvian Council of Science project lzp-2020/2-0073) “Sustainable urban development model compliant with UN settings“. The authors acknowledge the general financial support from company DPA Ltd (Latvia).

REFERENCES

1. Arcadis (2018). Citizen Centric Cities; the Sustainable Cities Index. https://www.arcadis.com/media/1/D/5/%7B1D5AE7E2-A348-4B6E-B1D7-6D94FA7D7567%7DSustainable_Cities_Index_2018_Arcadis.pdf
2. Bee smart city (2017). Building the Smart City: Advancing in Six Fields of Action. https://hub.beesmart.city/en/smart-city-indicators
3. de Boer, B., Hueting, R. (2004). Sustainable National Income and Multiple Indicators for Sustainable Development. In: Measuring Sustainable Development; Integrated Economic, Environmental and Social Frameworks. OECD Publishing, Paris; 39-52.
4. Bulkeley, H., Marvin, S. (2014). Urban Governance and Eco-cities: Dynamics, Drivers and Emerging Lessons. In: Hofmeister, W., Rueppel, P., Fook, L. L. (eds.). Eco-Cities: Sharing European and Asian Best Practices and Experiences. Singapore, European Union Centre; 19-34.
5. Burton, M., Kagan, C. (2009). Public policy initiatives and their impact on communities: challenges for community psychology. Manchester Metropolitan University. http://www.compsy.org.uk/pub%20pol%20paper.pdf
6. CITYkeys (2017). CITYkeys indicators for smart city projects and smart cities. https://nws.eurocities.eu/MediaShell/media/CITYkeysD14Indicatorsforsmartcityprojectsandsmartcities.pdf
7. CoE (1985). European Charter of Local Self-Government. Council of Europe. https://rm.coe.int/168007a088
8. EIU (2019). Global Liveability Index. Economist Intelligence Unit. https://www.eiu.com/public/topical_report.aspx?campaignid=liveability2019
9. Eurostat (2021). Sustainable development indicators. https://ec.europa.eu/eurostat/data/database

10. IMD (2019). IMD Smart City Index. https://www.imd.org/research-knowledge/reports/imd-smart-city-index-2019/
11. Karnitis, E., Bicevskis, J., Karnitis, G. (2021). Measuring the implementation of Agenda 2030 vision in its comprehensive sense: methodolo gy and tool. *Energies* 14, 856. DOI:10.3390/en14040856
12. Ritchie, H., Roser, M. (2020). Urbanization. OurWorldInData.org. https://ourworldindata.org/urbanization
13. Sarma, U., Karnitis, G., Zuters, J., Karnitis, E. (2019). District heating networks: enhancement of the efficiency. *Insights into Regional Development*, vol. 1(3), 200-213. DOI:10.9770/ird.2019.1.3(2).
14. Sasanpour, F. (2017). Liveable City One Step towards Sustainable Development. *Journal of Contemporary Urban Affairs*, vol. 1(3), 13-17. doi.org/10.25034/ijcua.2018.3673
15. Sharifi, A. (2020). A Typology of Smart City Assessment Tools and Indicator Sets. *Sustainable Cities and Society*, vol. 53, 101936. https://doi.org/10.1016/j.scs.2019.101936
16. UN (2015a). Transforming our world: the 2030 Agenda for Sustainable Development. UN General Assembly. https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E
17. UN (2015b). Sustainable cities and human settlements. UN Department of Economic and Social Affairs. https://sustainabledevelopment.un.org/topics/sustainablecities
18. UN (2017). New Urban Agenda. UN Conference on Housing and Sustainable Urban Development. https://habitat3.org/wp-content/uploads/NUA-English.pdf
19. UN (2019). World Urbanization Prospects, the 2018 Revision. Department of Economic and Social Affairs. https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf
20. Yakoub, W. A., et. al. (2019). Urbanism as it should be: an overview of Environmental Urban Movements and Initiatives towards Sustainability. Second International Conference (Tenth Conference of Sustainable Environmental Development) https://www.researchgate.net/publication/332159023_Urbanism_as_it_should_be_An_overview_of_Environmental_Urban_Movements_and_Initiatives_towards_Sustainability
21. Zuters J., Valeinis J., Karnitis G., Karnitis, E. (2016). Modelling of Adequate Costs of Utilities Services. In: Dregvaite, G., Damasevicius, R. (eds). Information and Software Technologies. ICIST 2016. Communications in Computer and Information Science, vol. 639. Springer, Cham. https://doi.org/10.1007/978-3-319-46254-7_1

APPENDIX

Designation		*Indicator*	*Source*
SDG3	**G3.1**	**Share of people with good or very good perceived health, % of population aged 16 or over**	Eurostat
	G3.2	Obesity rate by body mass index (BMI), % of population aged 18 or over	Eurostat
	G3.3	Self-reported unmet needs for medical examination and care, % of population aged 16 or over	Eurostat
	G3.4	Number of generalist medical practitioners, per 100 000 population	Eurostat
	G3.5	Neonatal mortality rate, per 1000 live births	WB
	G3.6	Under-five mortality rate, per 1000 live births	WB
	G3.7	Avoidable mortality, per 100 000 population below 75 years	Eurostat
SDG4	G4.1	Early leavers from education and training, % of population aged 18 to 24	Eurostat
	G4.2	Share of top performers in at least one subject (level 5 or 6)	OECD
	G4.3	Share of population with tertiary education (levels 5-8 ISCED 2011) from 15 to 64 years	Eurostat
	G4.4	Adult participation rate in education and training (last 12 months), from 25 to 64 years	Eurostat
	G4.5	Graduates in tertiary education, in science, math., computing, engineering, manufacturing, construction per 1000 of population aged 20-29	Eurostat
SDG5	G5.1	Gender pay gap in unadjusted form, % of average gross hourly earnings of men	Eurostat
	G5.2	Gap in higher educational attainment level, females - males, aged 15-64, percentage points	Eurostat
	G5.3	Gender employment gap, males - females, aged 15-64, percentage points	Eurostat
	G5.4	People gap with good or very good perceived health, males - females, population aged 16 or over, percentage points	Eurostat
	G5.5	Seats held by women in national parliament (%)	Eurostat
	G5.6	Percentage of women among elected local level representatives	CEMR
	G5.7	People gap /males-females/ with at least basic digital skills, 16-74 years old	Eurostat
SDG6	G6.1	Population having neither a bath, nor a shower in their dwelling, % of population	Eurostat
	G6.2	**Population not having indoor flushing toilet for the sole use, % of population**	Eurostat
	G6.3	Population connected to at least secondary wastewater treatment, %	Eurostat
SDG7	G7.1	Share of renewable energy in heating and cooling	Eurostat
	G7.2	**Share of population unable to keep home adequately warm by poverty status, %**	Eurostat
SDG8	G8.1	Employment rate, population from 20 to 64 years	Eurostat
	G8.2	Newly employed (percentage of people in current job for 12 months or less, in total employment), from 15 to 64 years	Eurostat
	G8.3	Long-term unemployment rate, % of active population from 15 to 74 years	Eurostat
SDG9	G9.1	Employment in high- and medium-high technology manufacturing and knowledge-intensive services; % of total employment	Eurostat
	G9.2	**Percentage of enterprises who have ERP software package to share information between different functional areas (10+ employees)**	Eurostat
	G9.3	Percentage of the gross value added by industry (B – E, NACE Rev.2)	Eurostat
	G9.4	Percentage of enterprises (10+ employees) having a fast (> 30 Mbit/sec) fixed broadband connection	DAS

	G9.5	Percentage of enterprises that provided any type of training to develop ICT related skills of their personnel	EIS
	G9.6	Percentage of SMEs who introduced at least one product innovation or process innovation either new to the enterprise or new to their market	EIS
	G9.7	Percentage of SMEs who introduced at least one new organisational innovation or marketing innovation.	EIS
	G9.8	Percentage of SMEs with in-house innovation activities	EIS
	G9.9	Total innovation expenditure as percentage of total turnover of enterprises, excluding intramural and extramural R&D expenditures	EIS
	G9.10	Percentage of SMEs with innovation co-operation activities	EIS
SDG11	G11.1	Population living in a dwelling with a leaking roof, damp walls, floors or foundation or rot in window frames of floor by poverty status, % of population	Eurostat
	G11.2	Young people neither in employment nor in education and training, from 15 to 24 years, percentage	Eurostat
	G11.3	Average number of rooms per person	Eurostat
SDG12	**G12.1**	**Recycling rate of municipal waste, % of generated**	Eurostat
	G12.2	Recycling rate of e-waste, %	Eurostat
SDG13	G13.1	Greenhouse gas emissions, tonnes per capita	Eurostat
	G13.2	Pollution, grime or other environmental problems, % of households	Eurostat
SDG15	G15.1	Share of forest area, % of total land area	Eurostat
SDG16	G16.1	Individuals interacting online with public authorities in the last 12 months, % of total	DAS
	G16.2	**Perceived independence of the justice system, % of population perceived as very good or fairly good**	Euro-barometer
	G16.3	Crime, violence or vandalism in the area, % of households	Eurostat
SDG17	G17.1	Households with fast (> 30 Mbit/sec) fixed broadband connection, % of total	DAS

Selected indicators of the sustainable development of cities.

Sources: CEMR – The Council of European Municipalities and Regions; DAS – the Digital Agenda Scoreboard; EIS – The European Innovation Scoreboard; OECD – The Organisation for Economic Cooperation and Development, WB – The World Bank.